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Geological Series.
Bulletin No. 2.

UNION OF SOUTH AFRICA

DEPARTMENT OF MINES

THE ANDALUSITE SANDS
OF THE
WESTERN TRANSVAAL

By

F. C. PARTRIDGE, M.Sc.

PUBLICATION OF THE GEOLOGICAL SURVEY DIVISION

The Government Printer, Pretoria
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.P.-S.3014—17/4/34—1,500.

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The Andalusite Sands of the Western Transvaal.

STATEMENT OF FACTS.

INTRODUCTION.

THE fact that andalusite occurred in small quantities in some sands of the Zeerust and Marico districts has probably been known for a long time. In recent years, however, several sands very rich in andalusite have been brought to my notice. As the quantity available was not known no further investigation of this material was made. It was considered to be local concentration in some watercourse. Some months ago Mr. Frommurze, while visiting the Marico-Bosveld Dam in the course of construction by the Irrigation Department, noted that a peculiar sand was being used on the works. A sample of this sand was obtained, and it proved to be very similar to those already in our possession. Considering the large quantities being used, it was thought that the sands might merit a closer investigation with a view to ascertaining whether material of sufficient purity for refractory purposes could be obtained from them.

All the samples examined were closely alike in constitution. Therefore the two which differed most in appearance were selected for closer investigation. The one appeared to be very much cleaner, purer and much better graded than the other. This sample was called No. 1. The darker sample was the material actually being used on the Marico-Bosveld Dam and was called No. 2.

METHOD OF TREATMENT.

Both the samples were given exactly the same treatment. The method used was an attempt to follow the principle of concentration adopted in ordinary mining practice. As small quantities were used and as a product approaching the ideal concentration was sought, separation with a liquid of high specific gravity was used instead of some method of gravity concentration. The liquid used was bromoform which had a specific gravity of 2·8. Samples of 100 grams (weighed exactly) were taken and thrown into a double separating funnel and bromoform was then added. When the layers were separate the heavier portion was dropped into the lower separator, which had been previously filled with bromoform. This broke up the mass and allowed any lighter grains, which had been caught up in the heavier mass, to be liberated. The fraction that floated in the upper separator was also submitted to a second bromoform treatment. The two light and two heavy fractions were then combined. The heavier fraction so obtained was further purified by submitting it to a strong magnetic field produced by an electromagnet. By this means magnetite and other oxides of iron, etc., were extracted. This latter treatment was necessary, as will be seen from the description under sample No. 1, because the heavy fraction obtained from the bromoform-separation was analysed and proved to be still too impure to be used as a refractory.

Each sample and fractions were also graded to see in which fractions, if any, more of the impurities were to be found. Solely from the point of view of mineralogical interest further separation was undertaken on all the portions obtained above, in order to ascertain the true mineralogical constitution of the sands. The results obtained were as follows:—

Sample No. 1.

Physical.—This sample was of bronze-brown colour with occasional black, brown, grey and white grains in it. It was composed largely of angular broken crystals of andalusite. There was a good percentage of other material usually much more rounded. The largest grain found was 5 mm. × 3·5 mm. The average grain size, as will be seen from the results below, was about 1·5 mm. diameter, and grains of between 0·5 mm. and 1·75 mm. formed the bulk of the material. The following was the mechanical composition of the sample:—

Grains with min. diam. greater than 1·75 mm. ... = 3·79%
Grains with min. diam. between 1·75 mm. and 0·75 mm. ... ... = 94·08% }
Grains with min. diam. between 0·75 mm. and 0·5 mm. ... ... = 1·49% } 95·57%
Grains with min. diam. less than 0·5 mm. ... ... = 0·64%

Mineralogical.—In the separation outlined above the fraction with specific gravity less than 2·87 formed 20·92 per cent. of the sample. It contained the following:—

Quartz and chert.
A few pieces of root and other organic remains.
Subangular fragments of fine-grained quartzite and sandstone, some of it ferruginous.
Irregular fragments of impure surface limestone.
Impure kaolinitic matter often stained by oxides of iron and/or manganese, and usually with very small grains of quartz in it.

The impure limestone was determined by treating the fraction with very dilute hydrochloric acid and carefully washing and drying what remained. This also removed all the organic matter. They formed 3·34 per cent. of the sample. The other materials were estimated by areally measuring them under a binocular and calculating the proportions. Their specific gravity differed so little that it was not necessary to recalculate their proportions by weight. The following are the proportions of the remainder of the light fraction, so obtained:—

Quartz: 25 per cent.
Quartzite and sandstone: 30 per cent.
Chert: 12½ per cent.
Impure kaolinitic matter: 12½ per cent.
Impure ferruginous matter and ferruginous quartzite and sandstone: 20 per cent.

The fraction with specific gravity greater than 2·87 is 78·64 per cent. of the sample. An analysis of this material by Mr. G. Mace, of the Consolidated Rand Brick, Pottery, and Lime Co., Ltd., at Olifantsfontein, was kindly placed at my disposal by Mr. D. Cullinan. It was as follows:—

SiO_2	34·62
TiO_2	0·04
Al_2O_3	54·04
Fe_2O_3	4·30
MgO	2·68
CaO	1·32
Loss on ignition	1·30
	98·30
Alkalis (by difference)	1·70

As this is too impure for refractory purposes, the sample was submitted to electromagnetic treatment.

The resultant magnetic fraction was 13·35 per cent. of the sample. It was mostly weakly magnetic and contained the following materials:—

Magnetite, limonite (impure hydrated ferric oxide), pyrolusite (impure).

The magnetite, extracted by a hand-magnet, was 0·13 per cent. of the sample. The remainder was hand-picked for the iron oxide and the manganese oxide grains. The fractions so obtained were respectively 59·04 per cent. and 40·96 per cent. of this remainder. These portions were chemically examined. The limonite contained at least 20 per cent. of impurity chiefly quartz grains, silica, and hydrated alumina silicates. There was very little manganese in it. The pyrolysite was rather purer, there being certainly less than 10 per cent. impurity, which consisted of silica, hydrated alumina silicates, and a very little oxide of iron. The manganese oxide grains were very irregular and little rounded. The limonite was much rounded and ovoid in form. These rounded grains on breaking showed very distinct concentric structure and their rounded nature was probably largely due to it.

The non-magnetic fraction was 65·29 per cent. of the sample. It consisted almost entirely of broken andalusite crystals and grains of altered shale. Less than 0·5 per cent. of this was due to shale grains. They were mainly siliceous, sericitic shale with a little ferruginous matter. There was also a little limestone with minute quartz grains and some kaolinitic matter.

The andalusite was mostly in the form of broken prismatic crystals. These did not show much rounding, but were pitted on the surfaces. They showed prism faces, but rarely terminations. It exhibited the following properties:—

Colour: Pink to bronzy brown.
Lustre: Vitreous.
Hardness: 7 +
Specific Gravity: 3·098 (corrected for water at 3·98° C.).
Streak: White.
Fracture: Uneven.
Cleavage: Good prismatic.

Crystal Habit: Prismatic first order prism. The angles measured on stage goniometer gave 87·5°, 88°, 88°, 88° orthorhombic.

Tenacity: Brittle.

Magnetic properties: Unaffected by strongest field of electromagnet.

Anisotropic.

Optical Character: Biaxial -ve.

Axial Angle: Large, judging from isogyres must be 2V near 90°.

Pleochroism: Faint: in thick fragments pale pink to colourless. X = rose-red; Y and Z = colourless.

Birefringence: ·010.

Extinction: Straight.

Refractive Indices: Nm = 1·639 ± ·002; Ng = 1·643 ± ·002.

An analysis of the material with specific gravity greater than 2·87 and non-magnetic, by Mr. H. G. Weall, Senior Chemist, Division of Chemistry, Capetown, gave the following results:—

SiO_2	40·9
TiO_2	0·2
Al_2O_3	56·95
Fe_2O_3	1·1
FeO	0·3
MnO	0·1
MgO	Very small trace.
CaO	Very small trace.
Alkalies	Very small trace.
Moisture	0·15
Loss on ignition	0·55
	100·25

This gives just over 90 per cent. theoretical Al_2SiO_5.

Some of the andalusite was cored with black. This dark centre was largely carbonaceous matter and disappeared on roasting, but some was certainly hydrated ferric oxide. There were also small irregular colourless anisotropic inclusions which largely consisted of quartz.

The mineralogical constitution by weight of the whole sample was as follows:—

Magnetite		= 0·13
Impure limestone		= 3·34
Organic matter		
Hydrated iron oxide chiefly as coating to grains		
Non-magnetic heavy fraction nearly pure Andalusite with a very few altered shale grains and a little shaly coating on Andalusite grains		= 65·29
Shale grains considerably less than 1 per cent.		
Lighter fraction other than limestone, etc.—		
Quartz	4·39	= 17·58
Quartzite and sandstone	5·27	
Chert	2·20	
Impure kaolinitic matter	2·20	
Impure ferruginous matter and highly ferruginous quartzite and sandstone	3·52	
	17·58	
Limonite		= 7·80
Pyrolusite		= 5·42
		99·56

The small loss of 0·44 grams in 100 grams is due to the very fine dust which blew off during handling or adhered to the filters and containers used.

The graded fractions were also mineralogically examined. The fraction +1·75 mm., 3·79 per cent. of the sample, contained only 0·29 per cent. of andalusite. The finest fraction −0·5 mm., 0·64 per cent. of the sample, contained less than 2 per cent. andalusite. Thus less than 0·02 per cent. of the sample was due to andalusite in this fraction. The other two fractions contained both the bulk of the andalusite and impurities, but no attempt was made to separate them. From a sieving of the separated fractions it was shown that of the 95·57 per cent. which forms the fractions between 1·75 mm. and 0·5 mm. 65 per cent. was andalusite, and 30·5 per cent. impurities. By sieving out the coarsest and finest fractions 4·12 per cent. of the 34·27 per cent. impurities would be removed and only 0·31 per cent. of andalusite lost.

SAMPLE No. 2.

Physical.—This sample was very dark brown to black in colour with occasional lighter-coloured grains visible in it. It was also composed largely of broken andalusite crystals, but these generally had a greater length in proportion to their width. There was a very much greater amount of finer material. The sample was not nearly so well graded. There was a fair proportion of fine grains of silt grade and the largest grain in the sample separated was 2 mm. × 8·8 mm. In addition to this there were larger grains which would not pass through the nozzle of the separating funnel and had to be sieved out. The largest obtained was 2·4 × 1·04 × 0·54 cms. The extracted grains formed 10·84 per cent. of the sample. They consisted of all the impurities found in the sand, but no andalusite. Impure limestone predominated. The mechanical composition of the sand was:—

Grains of min. diam. greater than 4 mm.	= 9·92%
Grains of min. diam. between 4 mm. and 1·75 mm....	= 13·76%
Grains of min. diam. between 1·75 mm. and 0·75 mm..	= 56·30%
Grains of min. diam. between 0·75 mm. and 0·50 mm.	= 14·14%
Grains of min. diam. lower than 0·50 mm.	= 5·88%

Again the bulk of the material was between 0·5 mm. and 1·75 mm. minimum diameter; but a good proportion, 16·43 per cent., was between 4 mm. and 1·75 mm. minimum diameter.

If the coarse material (minimum diameter: greater than 4 mm.) was first removed, as was done in the sample separated for analysis, then the remainder of the sample would have the mechanical composition given in "A" below. If 0·92 per cent. of the coarsest fraction were again removed, as was done before separation, then the mechanical composition would be as in "B" below.

	A.	B.
Grains of min. diam. between 4 mm. and 1·75 mm. ...	= 15·28%	14·50%
Grains of min. diam. between 1·75 mm. and 0·75 mm.	= 62·49%	63·07%
Grains of min. diam. between 0·75 mm. and 0·5 mm.	= 15·70%	15·84%
Grains of min. diam. below 0·5 mm.	= 6·53%	6·59%

Mineralogical.—As some of the grains would not pass through the nozzle of the separating funnel they were removed. These formed all of the coarser 9·92 per cent. and 0·92 per cent. of the next fraction. The percentages in the mineralogical separation are therefore quoted as percentages of the sand minus the 9·92 per cent. plus 0·92 coarser grains, and would compare with the percentages (mechanical separation) given under " B ". In the separation the fraction with specific gravity less than 2·87 formed 18·00 per cent. of the sample with the coarser grains (minimum diameter: greater than 4 mm., 9·92 per cent. and 0·92 per cent. of 1·75 mm. – 4 mm.) removed. The percentages of the sample quoted below for No. 2, will all refer to the sample with coarser grains removed. This light fraction contained the following materials:—

A few pieces of root and other organic remains.
Impure surface limestone.
Quartz and kaolinitic matter.
Altered shale (consisting chiefly of quartz, sericite and oxides of iron).
Sandstone and ferruginous sandstone.
Weathered talc-rock.
Weathered quartz-actinolite-rock.

The impure limestone was dissolved in very dilute hydrochloric acid and the residue washed and dried. This also removed the organic matter.

Together they formed 1·90 per cent. of the sample. No attempt was made to estimate the proportions and hence percentages of the other constituent materials.

The heavy fraction with specific gravity greater than 2·87 was 81·50 per cent. of the sample. This was not analysed but as the purer material was not good enough for commercial purposes, this was also submitted to electromagnetic treatment for further purification.

A complete magnetic fraction so obtained formed 31·91 per cent. of the sample, but part of this fraction was only extracted with difficulty in an attempt further to purify material submitted for analysis, which did not prove as good as sample No. 1.

The original magnetic fraction quite readily extracted by the electromagnet formed 7·02 per cent. of the sample. It consisted of the following materials:—

Magnetite, limonite, a little pyrolusite, ferruginous shale and a very little highly ferruginous andalusite.

The magnetite was extracted by a hand-magnet. It formed only 0·02 per cent. of the sample. The remaining 7·00 per cent. consisted of the ferruginous materials enumerated above, and no attempt was made to estimate the proportions.

An analysis (by Mr. H. G. Weall) of the remaining portion gave the following result:—

SiO_2	43·4
TiO_2	0·3
Al_2O_3	53·5
Fe_2O_3	1·1
FeO	0·6
MnO	0·15
CaO	Trace.
MgO	0·15
Alkalies	Very small trace.
Moisture	0·15
Loss on ignition	0·55
	99·9

This gives just over 85 per cent. theoretical Al_2SiO_5.

As this analysis was not as good as that of Sample No. 1 under the same treatment, an attempt was made to purify it further. It was therefore again submitted to electromagnetic treatment, this time to the strongest field obtainable. With difficulty a further weakly magnetic fraction was extracted. It formed 24·89 per cent. of the sample. It consisted mainly of impure ferruginous andalusite grains with a very small amount of impure oxide of iron, but no attempt was made to estimate their proportions.

A portion of this fraction was heated to dull redness for some time, and the electromagnetic treatment again tried. The whole reddened a good deal and portion of it was now as readily extracted as the original portion.

The readily extracted portion = 16·73% of the sample.
Extracted with difficulty, but even here more readily than before = 8·16% of the sample.

An almost negligible amount was non-magnetic, but this was probably due to a small impurity in the original material. The heat treatment made the material more readily magnetic.

Another portion of the fraction was treated with concentrated HCl and heated for some time. The resultant solution gave a large precipitate of iron. The residue was still magnetic, and when given the same heat treatment as the other portion it did not redden but was still magnetic.

Some of the heated material was also acid-treated. The solution gave a large iron precipitate. The dried residue was still magnetic, but not nearly so much stained by the oxide of iron.

The acid-treatment therefore cleaned the grains but only removed some of the iron content.

The fraction of the heavy material that was quite non-magnetic formed 49·59 per cent. of the sample. It consisted almost entirely of broken andalusite crystals mostly rather dark in colour as compared with Sample No. 1. The impurities were chiefly impure surface limestone and altered shale, and formed about 1 per cent. of this fraction. The andalusite crystals were seldom terminated and showed surface pitting but not much rounding. They exhibited the following properties:—

Colour: Almost black to bronzy pink.
Lustre: Vitreous.
Hardness: 7.
Specific Gravity: 3·061 (corrected for water at 3·98° C. There is more impurity than in No. 1; chiefly quartoze material).
Streak: Brownish to greyish-white.
Fracture: Uneven.
Cleavage: Imperfect prismatic.
Crystal Habit: Prismatic.
Tenacity: Brittle.
Magnetic Properties: Non-magnetic to greatest intensity field of electromagnet.
Anisotropic.
Optical Character: Biaxial -ve.
Axial Angle: Large, judging from curvature of isogyres near 2V 90°.

Pleochroism: Colourless to rose-red: X = rose red, Y and Z = colourless.
Birefringence: About ·010.
Extinction: Straight.
Refractive Indices: Ng = 1·641 ± ·002.
Nm = 1·638 ± ·002.

Under the microscope most of it was crowded with inclusions and often dark and almost opaque. Some such grains were crushed and heated for several hours. On examination it was found that nearly all the dark colour had disappeared so that most of this dark material was evidently carbonaceous matter. Only a little red-brown staining was left. This was shown to be ferric oxide. This clearing of the grains revealed many irregular colourless inclusions. Some of these were negative inclusions, but many were weakly anisotropic with refractive indices a good deal lower than the andalusite. They were apparently largely quartz.

To ascertain whether this final product was any purer, a partial analysis was undertaken by the writer with the following results:—

H_2O-	0·2
H_2O+	0·7
SiO_2	41·7
Al_2O_3 and Mn_2O_3	55·2
Fe_2O_3, including FeO	1·6
CaO	0·9
	100·3

This gives theoretical Al_2SiO_5 about 88 per cent.

This is poorer in iron and richer in CaO and H_2O than the analyses of the less pure material. There was evidently a good deal more surface limestone in this portion than that analysed by Mr. Weall. Part of the H_2O+ was due to CO_2 and the figures for SiO_2 are slightly high. There was a very small but almost negligible amount of MgO present.

The mineralogical constitution by weight of the whole sample was as follows:—

Magnetite	= 0·02%
Impure limestone, organic matter, hydrated iron oxide, mainly as grain coating	= 1·90%
Non-magnetic heavy fraction	
Nearly pure andalusite with a very few altered shale grains and a little shaly coating on andalusite grains	= 49·59%
Lighter fraction other than impure surface limestone consisting of quartz, quartzites, altered shale, talc rock, quartz-actinolite rock, kaolinitic matter, and a very little chert	= 16·10%
Limonite, other impure iron oxide, ferruginous shale, a very little pyrolusite and highly ferruginous andalusite	= 7·00%
Impure ferruginous andalusite and a very little impure oxide of iron	= 24·89%
	99·50%

The small loss, 0·50 gram in 100 grams, was due to the very fine dust which blew off during handling or adhered to the filters and containers used. It was slightly higher than in Sample No. 1 as there was considerably more fine material in the sample.

The various fractions referred to above were then graded by sieving. The following were the results:—

Wholly non-magnetic heavy fraction: 49·59 per cent.

Grains min. diam. below 0·5 mm. ... ... = 0·49%
Grains min. diam. between 0·5 mm. and 0·75 mm. ... = 3·60% }
Grains min. diam. between 0·75 mm. and 1·75 mm. ... = 38·28% } 41·88%
Grains min. diam. between 1·75 mm. and 4 mm. ... ... = 7·22% } 45·5%

Heavy fraction extracted with difficulty by electromagnet: 24·89 per cent.

Grains min. diam. below 0·5 mm. ... ... = 1·62%
Grains min. diam. between 0·5 mm. and 0·75 mm. ... = 7·60% }
Grains min. diam. between 0·75 mm. and 1·75 mm. ... = 15·31% } 22·91%
Grains min. diam. between 1·75 mm. and 4 mm. ... ... = 0·36%

Heavy fraction readily extracted: 7·02 per cent., but without magnetite 0·02 per cent. (0·5 – 0·75) or 7·00 per cent.

Grains min. diam. below 0·5 mm. ... ... = 0·69%
Grains min. diam. between 0·5 mm. and 0·75 mm. ... = 0·51%
Grains min. diam. between 0·75 mm. and 1·75 mm. ... = 3·53% }
Grains min. diam. between 1·75 mm. and 4 mm. ... = 2·27% } 5·80%

Light Fraction: 18 per cent., but without impure surface limestone and organic matter 1·90 per cent. (0·87>1·75, 1·00>0·75<1·75, 0·03<0·75).

Grains min. diam. below 0·5 mm. ... ... = 3·70%
Grains min. diam. between 0·5 mm. and 0·75 mm. ... = 3·75% }
Grains min. diam. between 0·75 mm. and 1·75 mm. ... = 4·89% } 8·64%
Grains min. diam. between 1·75 mm. and 4 mm. ... = 3·76% } 8·65%

As 0·92 per cent. of the 4 mm. – 1·75 mm. fraction was picked out by hand before the separation as well as the 9·92 per cent. coarser than 4 mm., these percentages are really of 89·16 per cent. of the complete sand.

An examination of the grades of the mechanically separated fractions showed no andalusite in the material of minimum diameter greater than 4 mm. In the finest grade (below 0·5 mm.) there was less than 5 per cent. of pure andalusite, but somewhat more clouded andalusite. The other three fractions contained a good deal of both andalusite and impurities.

The agreement with the mechanical grading was fair but not exact. Although the total of these fractions agreed with the separation total, the loss in that case was due to a very fine dust and would have been in the finest fraction, making it really 6·09 per cent., whereas the total of finest fractions is here 6·50 per cent., and all the totals of the other fractions are slightly less.

DEDUCTIONS.

It seems that material suitable for refractory purposes can be obtained from these sands. The andalusite in them is largely confined to certain grades. If the coarsest and finest grades alone were to be removed by sieving, some of the impurities in the sands could be extracted with little or no loss of good andalusite. The best grades to use are between ⅛-inch mesh and 40 mesh standard sieve. Both very fine and coarse material will thus be removed effecting a preliminary concentration. In Sample No. 1 about 5 per cent. of material would be removed with a loss of less than 0·5 per cent. of andalusite. In Sample No. 2 about 20 per cent. would be removed, with a loss of less than 3·5 per cent. of andalusite. This grading would also facilitate the subsequent separations, and is therefore very beneficial.

In Sample No. 1, 65 per cent. of the sand is suitable for use, giving a product with 90 per cent. theoretical Al_2SiO_5. Of the 35 per cent. impurity 5 per cent. can be removed by sieving. The remainder must be concentrated and electromagnetically separated. Roasting makes the electromagnetic separation easier, and the evenness of the grade of the material to be used should allow of ready concentration.

In Sample No. 2, 49 per cent. of the material is good, giving a product with 88 per cent. theoretical Al_2SiO_5, and possibly even 67 per cent. which gives only 85 per cent. theoretical Al_2SiO_5. In the first case some 30 per cent. of the impurities can be removed by sieving with a loss of 3·5 per cent. of the finished product, leaving at least 75 per cent. of good andalusite in the residue. The remainder must be concentrated and electromagnetically treated. The material is evenly graded and should also lend itself to concentration. Roasting greatly facilitates the electromagnetic separation and a still purer product can be obtained by acid-treatment.

These compare very favourably with the material supplied to the Champion Porcelain Company for spark-plug manufacture. This latter material is also said to give 90 per cent. theoretical Al_2SiO_5, but this has been raised by the presence of free Al_2O_3 (corundum) and probably other alumina silicates, whereas in the material referred to above the Al_2SiO_5 is all due to andalusite (the alumina-bearing impurities still left being negligible).

Large quantities of these sands are obtainable, and certainly were used on the Marico-Bosveld Dam. There is apparently much still available. Mr. A. J. Wells-Jones, the Resident Engineer, in a letter to Mr. Frommurze states:—

> "We have used on the Works 6,600 c. yards of the black sand which was all taken from the Wilgeboom Spruit, it is deposited all along the spruit in large quantities often to a depth of 6 to 7 ft. and we had no difficulty in getting it.
>
> There seems to be an inexhaustible supply and evidently comes from the hills lying west of Groot Marico and north of the Railway. I believe it occurs in Doorn River as well."

Some 2,970 c. yards of the purified product were therefore used on the Dam. At this rate over 7,500 tons of andalusite would have been obtained from this source alone.

Judging from the samples obtained from widely distributed points in this area, it must occur quite generally in the river beds of this district. Some sands are very much better than others, and can be purified with greater facility, but all are apparently amenable to treatment and will yield suitable products.

GEOLOGY AND NATURE OF OCCURRENCE.

A glance at the mineralogical compositions will show that these andalusite sands are extraordinarily free from other minerals of metamorphic origin. None of the minerals, except andalusite itself, common to the Inner (Hornfels) Zone of metamorphism of the Bushveld Aureole were found in the sands. Although such minerals as cordierite, which is very common in that Zone, were specially sought, none were obtained. The fragments of shale and other impurities attached to the andalusite are quartz-mica material or surface limestone and not cordierite material as would be expected if the andalusite was derived from the Inner Zone. It seems certain from these facts, together with the fact that the andalusite occurs as individual broken crystals and not in uneven and irregular fragments as would be expected if it came from the Hornfels Zone, that these sands were derived mainly from the weathering of altered shales belonging to the Chiastolite or Outer Zone of metamorphism of the Bushveld Aureole. In the districts referred to, this zone extends from below the Daspoort Quartzites to the Dolomite, and the andalusite-bearing slates are more particularly found between the Timeball Hill Quartzites and the Ongeluk Volcanics.

Hatch, Holmes, Hall and Humphrey have all noted and commented on the extraordinary development of chiastolite slates in this area, which they estimate to occur over many hundreds of feet in this horizon. There is thus a very large potential supply of this material. In none of the papers of the above writers is mention made of the presence of andalusite-rich sands.

The specific gravity, hardness and durability of andalusite renders it suitable for concentration by natural agencies. It suffers little or no alteration on exposure to the atmosphere, and its large size relative to the other fine-grained minerals, mainly quartz, mica and other micaceous minerals, accompanying it in the altered shales of this horizon, would tend to make it remain behind on weathering. The andalusite grains show very little or no rounding or waterwear in some cases, and very little in all. It is probable that the material has not been carried far from its source.

The occurrence would, therefore, be regarded as a residual concentration, but is partly also of alluvial origin, being concentrated in the form suitable for treatment, as far as we know, only in the river basins.

From the samples examined there appears to be a tendency to greater purity of andalusite itself (i.e. smaller incidence of inclusions) towards the Dolomite. Seemingly the less intense the metamorphism the less the andalusite itself is contaminated. The worst sample was obtained from the upper parts of this horizon on the farm Riekersdam, and the best from the edge of the Dolomite.

If one can give any indication as to where these sands may best be sought, the river valleys of the Great and Little Marico rivers and their tributaries would be stressed. From present information the most likely place where good material would be found is along the Doorn River especially where it flows over the lowest horizons of the Pretoria Series.

SUMMARY.

Mechanical and mineralogical analyses of the andalusite sands of the Zeerust and Marico Districts are given. It is shown that some of the andalusite is pure enough to be of use as a refractory, and that a fairly pure product can be obtained from these sands. Large

quantities have already been used in the course of dam construction by the Irrigation Department. Further attention on a commercial scale should certainly be given to these natural concentrations, especially as water is readily obtainable in this area, and all the likely localities are within easy reach and near the railway.

ACKNOWLEDGEMENTS.

In conclusion I wish to convey my thanks to Mr. H. F. Frommurze for drawing my attention to the quantities of these very interesting sands which occur in the Zeerust and Marico areas, and for obtaining a large sample of the material from the Marico-Bosveld Dam through the agency of Mr. A. J. Wells-Jones of the Irrigation Department.

I would also like to thank Mr. D. Cullinan for placing an analysis of the material at my disposal, and Mr. H. G. Weall for the careful analyses of the purified andalusite.

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